Department of Energy
Oak Ridge Office of Environmental Management
P.O. Box 2001
Oak Ridge, Tennessee 37831

PROGRAM	SITE	PROJECT #	FILE SEQUENCE

ROUTE TO: RCY

MAR 15 2019

March 14, 2019

CC | JBS

CERTIFIED MAIL

Ms. Constance A. Jones
Superfund Division
U.S. Environmental Protection Agency
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Atlanta Federal Center
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Atlanta, Georgia 30303-8960

Mr. Randy C. Young
State of Tennessee
Department of Environment and Conservation
Division of Remediation – Oak Ridge
761 Emory Valley Road
Oak Ridge, Tennessee 37830-7072

Dear Ms. Jones and Mr. Young:

TRANSMITTAL OF THE *FIELD SAMPLING PLAN FOR BASELINE GROUNDWATER AND SURFACE WATER CHARACTERIZATION AT THE PROPOSED ENVIRONMENTAL MANAGEMENT DISPOSAL FACILITY, OAK RIDGE TENNESSEE (DOE/OR/01-2812&D1)*

Enclosed please find the identified number of copies of the subject document and compact disks for your review. This plan describes the characterization effort to determine the groundwater and surface water chemistry baseline for the Central Bear Creek Valley location for the proposed Environmental Management Disposal Facility. Your review of this document does not indicate approval of the remedy decision associated with the Environmental Management Disposal Facility.

CERTIFIED – RETURN RECEIPT REQUESTED
(JONES 7009 2820 0001 9922 5642)
(YOUNG 7009 2820 0001 9922 5659)

TRANSMITTAL OF THE *FIELD SAMPLING PLAN FOR BASELINE GROUNDWATER AND SURFACE WATER CHARACTERIZATION AT THE PROPOSED ENVIRONMENTAL MANAGEMENT DISPOSAL FACILITY, OAK RIDGE TENNESSEE (DOE/OR/01-2812&D1)*

If you have any questions or if we can be of further assistance, please contact Brian Henry at (865) 241-8340 or John Michael Japp at (865) 241-6344.

Sincerely,

For Brian T. Henry
Portfolio Federal Project Director

John Michael Japp
Federal Facility Agreement Project Manager

Enclosures:
1. Document
2. CD

EPA: 1 (Enclosure 1), 2 (Enclosure 2)
TDEC: 2 (Enclosure 1), 1 (Enclosure 2)

cc w/enclosure 1:
Rhonda Butler, Value Added Solutions, plus 1 copy of Enclosure 2
SSAB

cc w/o enclosures:
Carl Froede, EPA Region 4
Susan DePaoli, Pro2Serve
Brad Stephenson, TDEC
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(YOUNG 7009 2820 0001 9922 5659)

DOE/OR/01-2812&D1

Field Sampling Plan for Baseline Groundwater and Surface Water Characterization at the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee

This document is approved for public release per review by:

Teresa D. Fancher 3/5/19

UCOR Classification & Information Control Office | Date

DOE/OR/01-2812&D1

Field Sampling Plan for Baseline Groundwater and Surface Water Characterization at the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee

Date Issued—March 2019

Prepared for the
U.S. Department of Energy
Office of Environmental Management

URS | CH2M Oak Ridge LLC
under contract DE-SC-0004645

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CONTENTS

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FIGURES

TABLES

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ACRONYMS

BCV	Bear Creek Valley
CBCV	Central Bear Creek Valley
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
COC	contaminant of concern
DOE	U.S. Department of Energy
DQO	data quality objective
EMDF	Environmental Management Disposal Facility
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
LLW	low-level (radioactive) waste
NT	Northern Tributary
NTU	nephelometric turbidity unit
OREIS	Oak Ridge Environmental Information System
ORP	oxidation-reduction potential
ORR	Oak Ridge Reservation
PEMS	Project Environmental Measurements System
PQL	project quantitation limit
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RCRA	Resource Conservation and Recovery Act of 1976
SMO	Sample Management Office
UTL	upper tolerance limit
WRRP	Water Resources Restoration Program
Y-12	Y-12 National Security Complex

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1. INTRODUCTION

The mission of the U.S. Department of Energy (DOE) Oak Ridge Office of Environmental Management is to decommission and demolish numerous facilities and conduct remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. This effort requires an estimated 2.2 million cy of landfill disposal capacity beyond what is available in the existing Environmental Management Waste Management Facility (EMWMF) for the disposal of wastes from CERCLA cleanup actions. The *Remedial Investigation/Feasibility Study for the Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge, Tennessee* (DOE 2017) evaluated several alternatives for the disposal of this waste, including no action, offsite disposal, and onsite disposal. As such, an approximately 70-acre tract in the Central Bear Creek Valley (CBCV) watershed has been proposed as the best site in terms of available capacity and location for an onsite landfill, termed the Environmental Management Disposal Facility (EMDF).

The proposed EMDF (Site 7c) is located in CBCV west of the Y-12 National Security Complex (Y-12) on the ORR (Fig. 1). The conceptual design is based on a total constructed volumetric capacity of approximately 2.2 million cy. EMDF will be equivalent to a Resource Conservation and Recovery Act of 1976 (RCRA) landfill, similar to EMWMF, and will accommodate disposal of both low-level (radioactive) waste (LLW) and mixed LLW, some of which may be classified.

This Field Sampling Plan (FSP) provides for baseline groundwater and surface water characterization for EMDF. The companion document to this FSP, *Quality Assurance Project Plan for the Water Resources Restoration Program, U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee* (QAPP) (UCOR, an AECOM-led partnership with Jacobs, 2014), contains references to the sampling procedures.

After disposal operations begin, monitoring will be performed at EMDF to obtain the groundwater sampling and analysis data needed to ascertain if hazardous constituents derived from wastes managed and disposed at EMDF have entered the uppermost aquifer. This determination will be based on the comparison of monitoring results to baseline threshold/evaluation data. The groundwater sampling and analysis requirements described in this FSP comply with RCRA general groundwater monitoring requirements defined by the U.S. Environmental Protection Agency (EPA) under 40 *Code of Federal Regulations* (*CFR*) 264.97. These performance standards and associated data assessment/acceptance criteria are intended to ensure that baseline groundwater characterization is based on monitoring results that meet the applicable data quality objectives (DQOs) discussed in Sect. 2. This FSP also defines baseline characterization requirements for sampling/analysis of surface water in the northern tributaries of Bear Creek near EMDF. Surface water monitoring is included because groundwater from the uppermost aquifer primarily discharges to surface water features.

This FSP focuses on defining baseline groundwater and surface water conditions and describes the objectives, requirements, and approach to collecting baseline groundwater characterization data for EMDF. Baseline characterization will enhance the ability to evaluate groundwater compliance monitoring data collected during operations and as the facility enters post-closure care. This FSP is not the EMDF groundwater monitoring plan for evaluating compliance, which will be included with future EMDF design submittals.

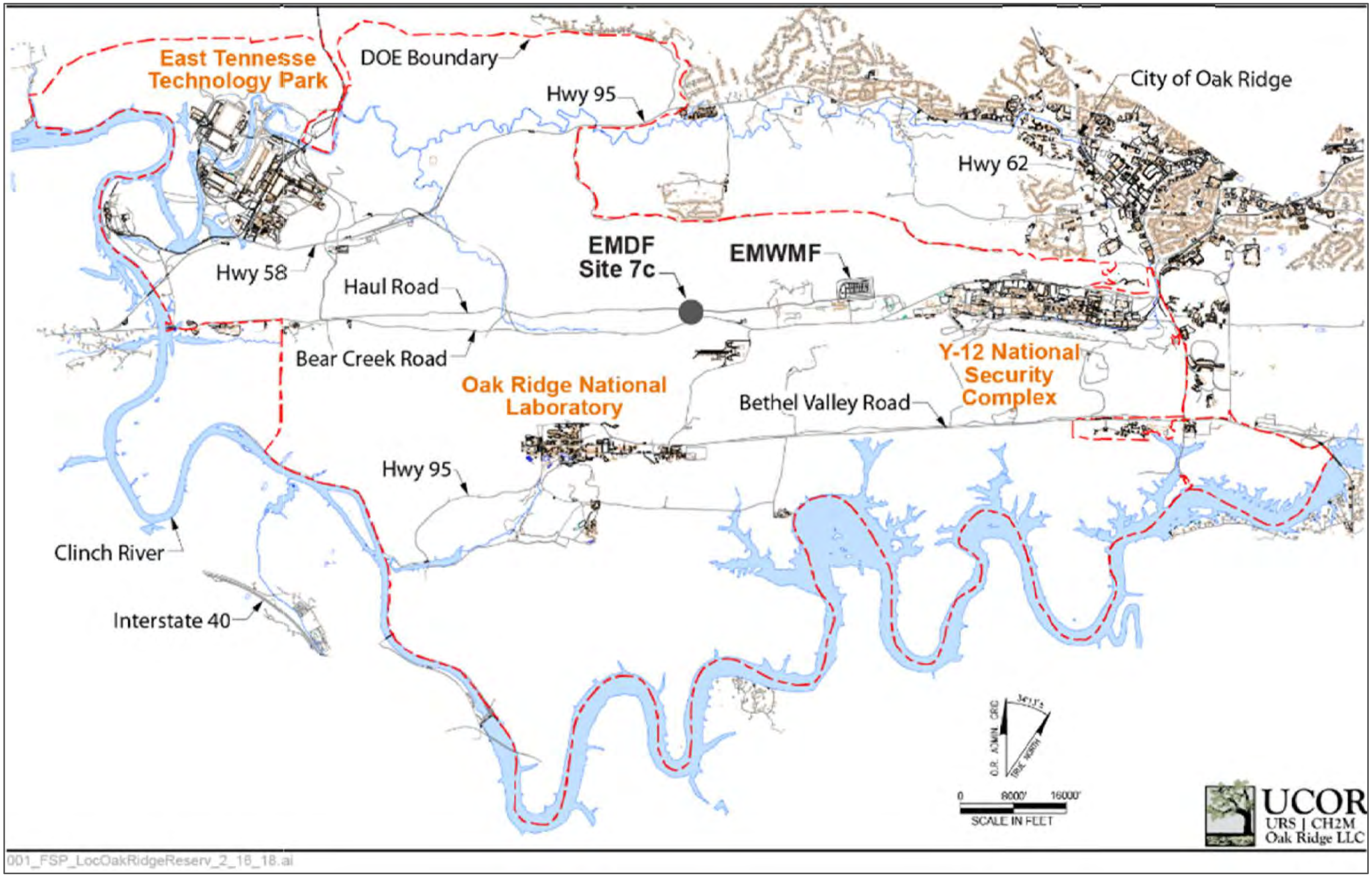

Fig. 1. Oak Ridge Reservation with proposed EMDF location.

The EMDF project will interface with the ORR Water Resources Restoration Program (WRRP), as necessary, during implementation of the QAPP as it relates to groundwater and surface water monitoring.

The site proposed for the EMDF is situated within an upland area located between north-south trending valleys of Northern Tributary (NT)-10 and NT-11. The site and surrounding areas are forested, except for areas along the south side between the Haul Road and Bear Creek Road, where the area has been cleared. Other surface water conveyances within the site are D-10W, parallel to and just west of NT-10, and D-11E, an east-west trending feature that drains westward into NT-11 near the center of the site.

The Bear Creek Valley (BCV) Remedial Investigation Report (DOE 1997) included a hydrogeological conceptual model that integrated existing contaminant source areas and groundwater plumes within the overall context of the geology, and surface water and groundwater hydrology of the BCV watershed. Most relevant to the EMDF site, the conceptual model addressed the surface and subsurface flow conditions within and across the predominantly clastic formations of the Rome, Pumpkin Valley, Rutledge, Rogersville, Maryville, and Nolichucky formations that underlie most of the valley floor, and those within and across the predominantly carbonate formations of the Maynardville Limestone and lower Copper Ridge Dolomite that underlie a more narrow swath along the southern part of BCV.

The BCV conceptual model, which includes the EMDF site, makes an important distinction between surface water flow along the NTs to Bear Creek and groundwater flow within and across the outcrop belts of predominantly clastic rocks, versus surface water flow along Bear Creek and groundwater flow within the karst conduit network of the Maynardville Limestone. The groundwater flow paths through regolith materials and bedrock fractures within the predominantly clastic rocks differ from that of the karst network of the Maynardville. Across the clastic outcrop belts, overall shallow/intermediate level groundwater tends to flow south to southwest, whereas flow within the Maynardville and along Bear Creek tends to follow the geologic strike toward the southwest.

Key elements of the conceptual site model for EMDF site are shown in Fig. 2. The footprint for EMDF predominantly overlies southeastward dipping bedrock of the Conasauga Group, including the Rutledge Formation, Rogersville Shale, Maryville Formation, and Nolichucky Shale (Fig. 2). These formations in the Conasauga Group are predominantly shales, siltstones, and mudstones, with some interbedded limestone. There is little limestone present in the bedrock underlying the proposed facility, even in the Maryville Formation. The crest of the knoll below the north center of the footprint is underlain by the erosion-resistant Maryville Formation. The typical weathering profile of topsoil, silty/clayey soil residuum, saprolite, and fractured bedrock occupy the undisturbed site areas.

In BCV, the average dip of the strata is 45° southeast. Some microfolds to mesofolds are present. Fractures are present within the bedrock and exert substantial control on the location of the tributaries. These fractures and macro/micropores within the soils/saprolite and bedrock provide the primary routes for groundwater flow (and contaminant transport) (DOE 2016).

The depth to the water table or thickness of the unsaturated zone at the EMDF site varies with the topography. Vadose zone thickness is greatest below upland recharge areas such as those along the ridges of the Maryville Limestone outcrop belt. Away from these upland areas, the vadose zone thins into groundwater discharge zones along the NT valley floors where the water table is at or near the ground surface. The majority of flow from upland areas is directed towards the valley axis by the NTs to Bear Creek. Groundwater within the saturated zone converges and discharges slowly into NT stream channels supporting base flow along the valley floors, particularly during the wet season. During drier periods, groundwater may make little or no contributions to stream channel base flow, but may continue to slowly migrate southward toward Bear Creek along the NT valley floor areas within alluvium, saprolite, and bedrock fractures below the active stream channels.

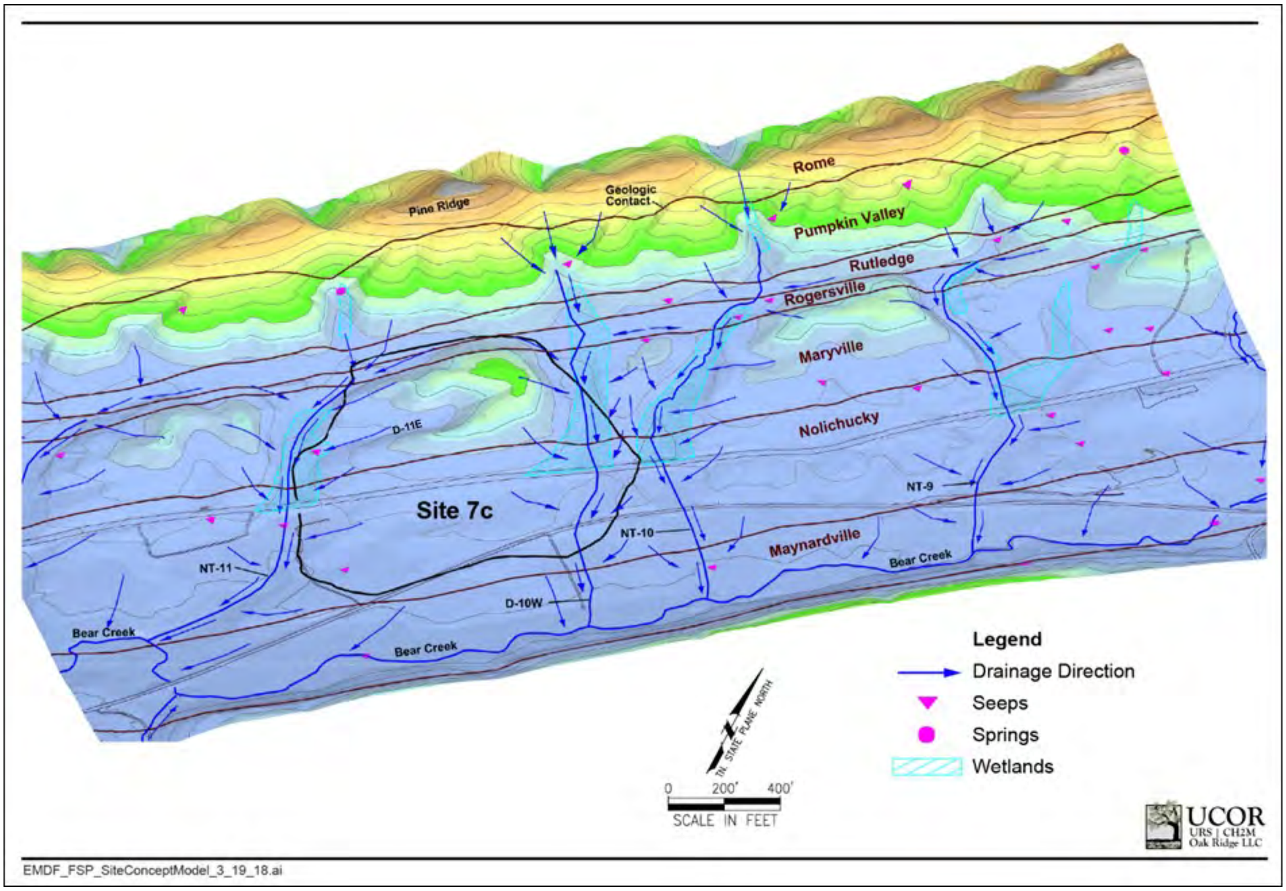

Fig. 2. Generalized flow paths for shallow/intermediate groundwater.

A smaller portion of the groundwater below the EMDF site (groundwater that does not readily discharge along strike to the NT valleys) moves southward toward Bear Creek along less dominant fracture pathways oriented perpendicular to geologic strike. Groundwater in bedrock that does not discharge directly to surface water (e.g., deep groundwater zones) can exhibit an upward gradient because of the pressure gradient from recharge along Pine Ridge and discharge into the Bear Creek–Maynardville Limestone drainage system, which is the regional discharge area for BCV. Bear Creek flows toward the west more or less continuously over non-karst bedrock, but loses flow to subsurface conduits where it crosses karst features in the Maynardville Limestone.

2. DATA QUALITY OBJECTIVES

The DQO process provides a structured approach to planning projects where data are used to support environmental decisions and evaluations. Use of the DQO process leads to efficient and effective expenditures of resources; consensus on the type, quality, and quantity of data needed to meet the project goals; and full documentation of actions taken during development of the project. DOE has applied the concepts defined in *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006) to the qualitative assessment of data needs.

These DQOs will support the collection, analysis, and evaluation of groundwater and surface water chemistry and constituents for initial development of baseline conditions for selected contaminants of concern (COCs). This is separate from a groundwater monitoring plan for compliance monitoring. Predisposal monitoring data will be used to develop a baseline for comparison with operational and post-operational monitoring results. Baseline groundwater and surface water characterization will begin during planning and development of the proposed disposal and support facilities.

2.1 DQO STEP 1: STATE THE PROBLEM

Data are needed to establish the baseline levels of naturally occurring constituents, including chemical and radionuclide constituents, in the vicinity of EMDF and evaluate whether other upgradient sources of groundwater and/or surface water contamination are present and, if so, impacting the facility footprint. Groundwater and surface water quality data will include landfill-specific constituents, selected COCs related to past operations, activities and known contaminants in upgradient groundwater, and general groundwater chemistry. This will provide the data for initial conditions to be used in supporting future compliance monitoring plans. This data need is related to developing threshold levels, or evaluation levels, for chemicals and radionuclides present in the groundwater or surface water prior to operation of EMDF.

Data needs are addressed in the following Problem Statement:

> *Groundwater and surface water data of sufficient quality and quantity are needed to establish baseline conditions and support future evaluation and assessment of potential adverse impacts to human health and the environment resulting from operation of the EMDF.*

2.2 DQO STEP 2: IDENTIFY THE GOAL OF THE STUDY

The purpose of DQO Step 2 is to define the principal study questions that need to be answered to address the problem identified in DQO Step 1. Principal study questions help focus the search for information that will address the problem. For the problem defined above, the principal study questions include the following:

- What are the baseline conditions?
- What is an appropriate monitoring network for establishing baseline?
- How do the existing, or baseline, chemical and radionuclide concentrations in groundwater and surface water vary spatially and temporally in the vicinity of the EMDF?

The primary goal is to implement groundwater and surface water quality monitoring to generate representative data needed to provide for reliable baseline conditions for potential COCs derived from wastes disposed in EMDF that may be released to the groundwater flow system or from contaminant sources upgradient of the proposed facility. Analytical data will be used to evaluate the general groundwater and surface water chemistry and estimate the distribution of COCs in the vicinity of EMDF (upgradient and downgradient). The outcome will be an appropriate statistical measure of the distribution of COCs, along with a threshold value (e.g., upper tolerance limit [UTL], etc.) calculated on that measure to reflect uncertainty.

2.3 DQO STEP 3: IDENTIFY INFORMATION INPUTS

Inputs for the principal study questions include the following:

1. The conceptual site model
2. Information related to adjacent (particularly upgradient) contamination sources
3. Groundwater quality data from wells located in the vicinity of EMDF (upgradient and downgradient) in the shallow water table and deep groundwater zones and existing surface water data
4. Static water level elevations (potentiometric data) from wells/piezometers located near EMDF, including wells located hydraulically upgradient and downgradient
5. Potential COCs for baseline determination.

2.4 DQO STEP 4: DEFINE THE BOUNDARIES OF THE STUDY

The following were considered in defining the areal boundaries for baseline characterization:

- Upgradient (topographic saddle on Pine Ridge on the north side of EMDF)
- Downgradient (Bear Creek, with special attention to the Nolichucky/Maynardville contact)
- Lateral (within 400 ft east of NT-10 and 400 ft west of NT-11).

The vertical boundaries are defined as the uppermost saturated unit, including the shallow zone at the saprolite/bedrock interface, and a deeper bedrock zone approximately 50 ft below that surface. For the temporal boundaries, analytical data is needed over a minimum of four quarters prior to facility operation.

2.5 DQO STEP 5: DEVELOP THE ANALYTIC APPROACH

The collected data will be used to provide distribution information on the potential COCs and arrive at an estimate of population parameters for baseline characterization. Analysis and interpretation of groundwater and surface water characterization data will be obtained to establish baseline groundwater conditions for EMDF.

The planned characterization approach will be groundwater and surface water monitoring to establish baseline conditions. Monitoring locations and analyses will be described in a baseline characterization FSP (this document) and include surface water and both the shallow water table and bedrock groundwater zones. The baseline characterization data will provide the basis for establishing threshold/evaluation values.

2.6 DQO STEP 6: SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

Performance criteria, with the appropriate level of quality assurance (QA) practices, guide the design of data collection efforts, while acceptance criteria guide the design of procedures used to acquire and evaluate data relative to its intended use.

Threshold/evaluation values will be developed for use as the basis for comparison of baseline conditions to data generated from future EMDF monitoring events. The threshold/evaluation values will represent either baseline concentrations (for naturally occurring constituents) or project quantitation limits (PQLs) for non-naturally occurring constituents. DOE will monitor baseline levels for a minimum of four quarters prior to the start of operations (i.e., four quarters for 1 year). After the first year of sampling, baseline characterization sampling will continue semi-annually until the detection/operation monitoring program for EMDF is implemented. Important considerations in collecting data and developing threshold/evaluation values include the following:

- Detection limits appropriate to meet PQLs
- Use of approved analytical methods
- Quality of analytical laboratories
- Approved procedures for monitoring/sample collection
- Statistical approach for developing threshold/evaluation values.

Where possible, threshold values will be calculated using UTLs for each COC in the proposed baseline monitoring wells. Surface water data will be evaluated separately from the groundwater data. Prior to developing the threshold values, distribution of analytical data for each parameter in the 14-well aggregate or surface water aggregate will be evaluated along with the presence of any outliers. Use of UTLs for comparative criteria is consistent with RCRA guidance under 40 *CFR* 264.97(h). Final threshold/evaluation values will be proposed for regulatory approval.

2.7 DQO STEP 7: DEVELOP THE PLAN FOR OBTAINING DATA

This baseline characterization FSP includes the drilling and installation of 14 groundwater monitoring wells (six shallow/deep monitoring well pairs and two shallow monitoring wells) outside the perimeter landfill berms or area affected by landfill construction. The general locations of the monitoring wells and surface water locations proposed for baseline characterization are shown on Fig. 3. Final baseline monitoring well locations will be determined in the field based on accessibility and site conditions. Monitoring well locations also may be adjusted to accommodate the design of support facilities and infrastructure. The baseline monitoring wells are not being proposed as compliance monitoring wells for EMDF during operations. If appropriate, some of these baseline monitoring locations could be used for compliance monitoring in the future.

A series of tributaries, numbered in ascending order downstream from the creek headwaters at the west end of Y-12, traverse the southern flank of Pine Ridge. Two surface water sampling stations will serve the purposes of baseline characterization at EMDF: SF-1 on NT-11 and SF-6 on NT-10. These two surface water stations are located at flumes installed in the tributaries during a previous hydrogeological characterization project.

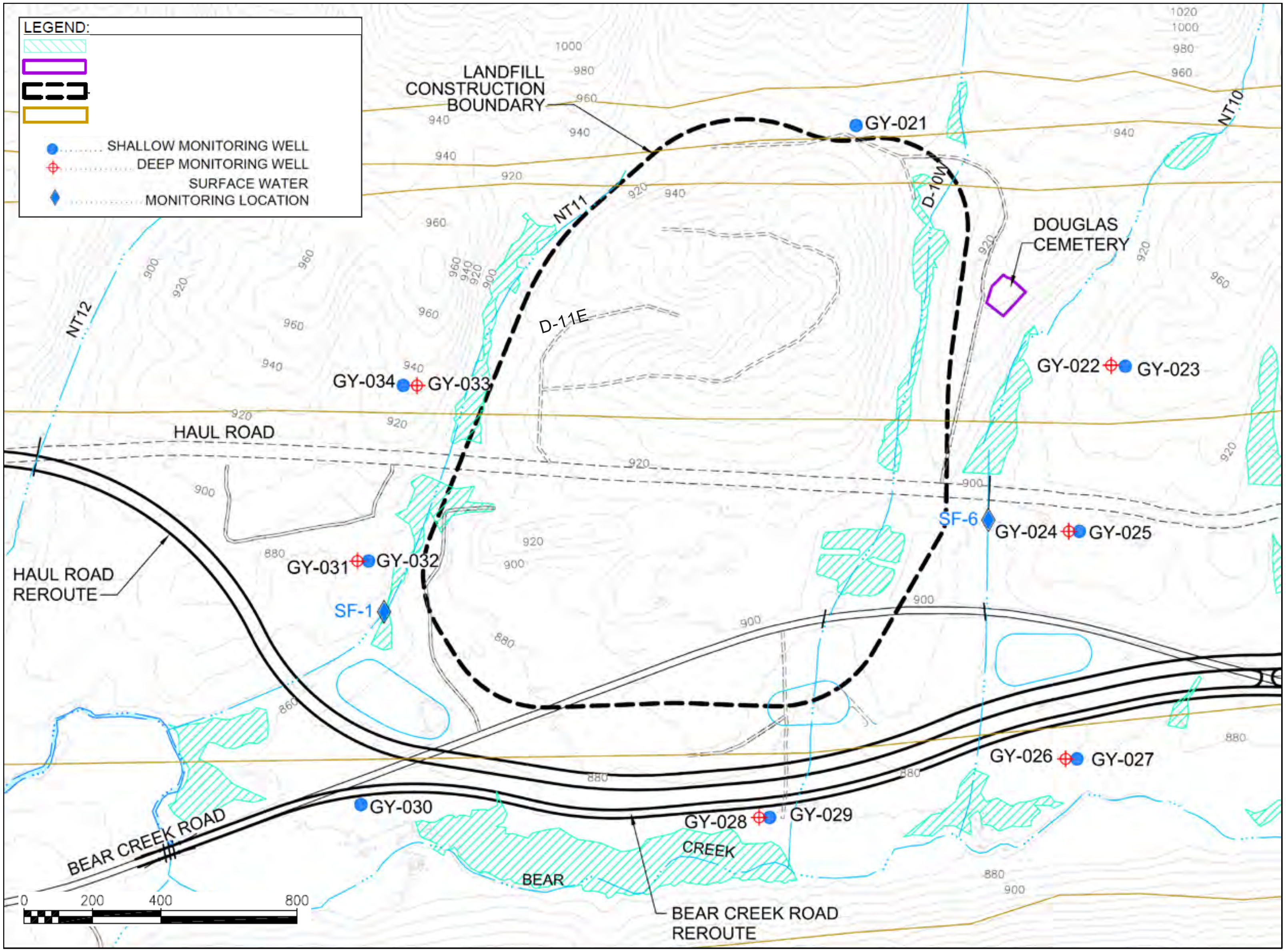

Fig. 3. Baseline monitoring locations.

The specific requirements applicable to the collection of groundwater and surface water sampling data for the purposes of baseline characterization at EMDF are described in this FSP and the WRRP QAPP. These documents identify required sampling protocols, technical procedures and sampling/analysis methods (including field and laboratory QA and quality control [QC] sampling requirements), data acceptance criteria, and data evaluation.

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3. BASELINE MONITORING APPROACH

Sampling and analysis requirements for baseline characterization at EMDF comply with RCRA applicable or relevant and appropriate requirements (i.e., 40 *CFR* §264.97[g]). The monitoring approach is intended to provide a framework for consistent sampling and analysis designed to ensure monitoring provides an accurate representation of groundwater and surface water conditions in the vicinity of EMDF.

3.1 MONITORING NETWORK

EMDF is located in the CBCV watershed. Hydrogeologic data from site characterization studies have been used to identify monitoring well locations and groundwater sampling depths to provide reliable information concerning the pre-existing chemical and radiological constituents in groundwater as well as contaminants that may be entering the EMDF vicinity from upgradient sources.

A summary of monitoring well installation parameters (e.g., screen intervals) is provided in Table 1. Baseline groundwater characterization monitoring wells will be installed upgradient, downgradient, and lateral to EMDF and will monitor both shallow and deep groundwater zones. However, these monitoring wells are not being proposed as compliance monitoring wells for EMDF. The compliance monitoring network will be part of the EMDF design package. Placement and targeted depth of screening for baseline characterization monitoring wells was developed based on prior hydrogeological characterization of the area in which EMDF is to be constructed. Baseline monitoring locations were selected to avoid wetlands, to be located beyond the limits of disposal cell construction to avoid future disturbance, and to avoid future road rerouting activities. Final monitoring well locations will be determined in the field based on accessibility and site conditions, and locations will be surveyed by a licensed land surveyor following installation.

Wells installed in the Maynardville Limestone south, or downgradient, of EMDF will obtain baseline data from an area noted to have "periodic plume extension" from the upgradient groundwater plumes migrating along BCV (DOE 2018). The *Groundwater Strategy for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2014) identifies this data gap concerning quantifying the nature and extent of groundwater contaminant migration southwestward along the valley axis.

The 30-ft screening interval for the deeper bedrock wells was selected to maximize the range for collecting groundwater and increase the opportunity for detecting any constituents that may be present. Deep monitoring well screen interval depths are based on current EMDF design information and data collected during geotechnical and hydrogeological characterization projects (e.g., groundwater levels, transmissive zones, etc.).

The shallow monitoring wells will be screened at, or just below, the saprolite/bedrock interface and have 15-ft screening intervals (estimated screen interval depths provided in Table 1 may be changed in the field during installation based upon field conditions). The 15-ft screen interval should be adequate for intersecting fractures within the upper portion of the bedrock and any saturated groundwater zones at the saprolite/bedrock interface.

Monitoring wells with 2-in. stainless steel casings and screens will be installed by Tennessee-qualified monitoring well drillers in accordance with ORR requirements as specified in *Standard Specification for Well Drilling, Installation, and Abandonment* (UCOR 2016).

Table 1. Estimated monitoring well installation depths and screen intervals

Well ID	Geologic formation	Shallow/ deep	Estimated ground elevation	Estimated screen interval	Screen length (ft)	Location rationale	Estimated drilling depths (ft)
GY-021	Rutledge	S	955	930-915	15	Upgradient	40
GY-022	Maryville	D	935	870-840	30	Lateral (east)	95
GY-023	Maryville	S	935	905-890	15	Lateral (east)	45
GY-024	Nolichucky	D	905	855-825	30	Lateral (east)	80
GY-025	Nolichucky	S	905	885-870	15	Lateral (east)	35
GY-026	Maynardville	D	878	810-780	30	Downgradient	98
GY-027	Maynardville	S	878	855-840	15	Downgradient	38
GY-028	Maynardville	D	870	810-780	30	Downgradient	90
GY-029	Maynardville	S	870	850-835	15	Downgradient	35
GY-030	Maynardville	S	865	850-835	15	Downgradient	30
GY-031	Nolichucky	D	885	845-815	30	Lateral (west)	70
GY-032	Nolichucky	S	885	870-855	15	Lateral (west)	30
GY-033	Maryville	D	930	860-830	30	Lateral (west)	100
GY-034	Maryville	S	930	905-890	15	Lateral (west)	40

D = deep
ID = identification
S = shallow

Surface water sampling will occur at two flumes (SF-1 located on NT-11 and SF-6 located on NT-10) installed during a previous hydrogeological characterization project.

3.2 SAMPLE FREQUENCY TO ESTABLISH BASELINE

Baseline characterization will begin at least one year prior to operation of EMDF to provide a minimum of four quarters of sampling results (i.e., four quarters for 1 year). After the first year of sampling, baseline characterization sampling will continue semi-annually until the detection/operation monitoring program for EMDF is implemented. During each sampling event for establishment of the baseline, groundwater and surface water samples from all applicable locations will be collected over a short period of time. Groundwater and surface water samples will be obtained during the same sampling event, unless insufficient surface water flow is available due to dry weather. In such instances, the field personnel will log the date and time of the sampling attempt and the observation that the station is dry.

3.3 CONTAMINANTS OF CONCERN

The parameters, or constituents, for analysis are provided for baseline determination of the groundwater and surface water characteristics in the EMDF area. Potential COCs for baseline characterization were identified for EMDF based upon potential abundance in the projected waste (using process knowledge from EMWMF and potential future source inventory for EMDF), mobility, and/or potential risk, and based on contaminants known to be present in identified groundwater plumes in BCV (primarily volatile organic compounds, nitrate, and radionuclides). The potential COCs for determining the baseline conditions are provided in Table 2. After the first year of characterization, the COC list will be evaluated to determine a subset of COCs for continued monitoring until the detection/operation monitoring program for EMDF is implemented.

Table 2. COCs for baseline characterization

Metals			
Arsenic	Chromium (VI)	Nickel	Uranium
Barium	Copper	Selenium	
Cadmium	Lead	Silver	
Chromium	Mercury	Thallium	
Radionuclides			
Carbon-14	Strontium-90	Thorium-230	Uranium-235/236
Cesium-137	Technetium-99	Tritium	Uranium-238
Iodine-129	Thorium-228	Uranium-233/234	
Volatile organic compounds			
1,1,1-Trichloroethane	1,2-Dichloroethene	Chloroethane	Trichloroethene
1,1-Dichloroethane	Acetone	Chloroform	Vinyl chloride
1,1-Dichloroethene	Benzene	Tetrachloroethene	
1,2-Dichloroethane	Carbon tetrachloride	*trans*-1,2-Dichloroethene	
Pesticides and PCBs			
4,4’-DDD	Chlordane	Lindane (gamma-BHC)	PCB-1254
4,4’-DDE	Dieldrin	PCB-1016	PCB-1260
4,4’-DDT	Dioxin	PCB-1221	PCB-1262
Aldrin	Endosulfan II	PCB-1232	PCB-1268
alpha-BHC	Endrin aldehyde	PCB-1242	
beta-BHC	Heptachlor epoxide	PCB-1248	
Semivolatile organic compounds			
1,4-Dichlorobenzene	Benzidine	Benzo(k)fluoranthene	Dibenz(a,h)anthracene
3,3-Dichlorobenzidine	Benzo(a)pyrene	Benzoic Acid	Indeno(1,2,3-cd)pyrene
Benz(a)anthracene	Benzo(b)fluoranthene	Chrysene	Pentachlorophenol
Other			
Calcium	Cyanide	Potassium	Total dissolved solids
Carbonate/bicarbonate	Magnesium	Sodium	
Chloride	Nitrate	Sulfate	

BHC = benzenehexachloride
COC = contaminant of concern
DDD = dichlorodiphenyldichloroethane
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethane
PCB = polychlorinated biphenyl

4. SAMPLE PLANNING, COLLECTION, AND ANALYSES

Qualified and trained personnel with all specialized training requirements will perform all field activities in accordance with the most recent version of procedures specified in the QAPP or EPA-approved technically equivalent procedures.

4.1 GROUNDWATER

4.1.1 Groundwater Level Measurement

Depth-to-water in monitoring wells will be measured to the nearest 0.01 ft using an electronic water level indicator at the beginning of each sampling event (prior to purging) in accordance with procedure PROC-ES-2100, *Groundwater Level Measurement*. All depth-to-water measurements collected for a sampling event will be recorded in a field logbook or on an appropriate field data form.

4.1.2 Well Purging and Sampling

Baseline groundwater characterization activities will be conducted under the ORR WRRP QAPP. Well purging and sampling will follow approved procedure PROC-ES-2101, *Groundwater Sampling Wells or Piezometers*.

The pump intake will be positioned near the approximate midpoint of the screened interval. Purging will be completed using dedicated bladder pumps installed in each monitoring well. Depending on the recharge capacity of the monitoring wells, either low-flow, minimal drawdown sampling (micropurging), or conventional three-casing volume purging and sampling methods will be used as specified in the sampling procedure. The initial purging attempts will be performed using the micropurge method, the preferred method, to determine if the well can be purged without inducing excessive drawdown. If maintaining drawdown to within specifications is difficult, the conventional three-casing volume method will be used instead. The selected purge method for each monitoring well will be used for subsequent monitoring events.

Under the conventional three-volume purge method, the well is purged until a minimum of three times the volume of water within the inner casing is removed and the selected indicator parameters have stabilized or the well goes dry. For the three-volume purging methods, indicator parameter stabilization is defined as pH +/- 0.1 unit, specific conductance +/- 10 percent, constant temperature over three consecutive readings, and turbidity less than 10 nephelometric turbidity units (NTUs).

For the micropurging sampling method, monitoring wells are purged at a low rate (typically 300 mL/min or less) to ensure minimal drawdown of the water level in the well (< 0.1 ft per quarter hour). Groundwater samples are collected upon stabilization of water levels and selected indicator parameters over four consecutive readings at 5-minute intervals (pH +/- 0.1 unit, specific conductance +/- 10 percent, constant temperature over three consecutive readings, and turbidity less than 10 NTUs).

4.2 SURFACE WATER

Surface water samples will be obtained in accordance with the container submergence (grab sampling) method described in PROC-ES-2203, *Surface Water Sampling – Manual and Automated*. Surface water samples will be collected during the same sampling event as the groundwater samples. If surface water flow is insufficient due to dry weather, the field personnel will log the date and time of the sampling attempt and the observation that the station is dry.

4.3 SAMPLE DOCUMENTATION, PACKING, AND SHIPMENT

The selection criteria for the appropriate sample containers, sample preservatives, and holding times shall be in accordance with the WRRP QAPP and EPA guidance. Sample containers, preservatives, and holding times are specified in the WRRP QAPP (Table D.49). The sample volume to be collected is dependent on the methodology to be used and the specific minimum detection levels. The laboratory typically provides this information prior to a project laboratory readiness review. Types of sample containers and sample preservation methods used will be documented in the field logbook and/or on the chain-of-custody form. The chain-of-custody forms will indicate the sample holding time prior to analyses.

The chain-of-custody control is critical for documenting the integrity of the samples following collection, during transport to the laboratory, and at the laboratory. Consequently, the label for each sample container shall be completed to document the sample collection activities. After labeling the sample containers, the sample numbers should be documented on the chain-of-custody form prior to mobilization to the next sample point. In addition, the chain-of-custody form will be signed by the sampling personnel and the receiving agent with the date and time of transfer noted. The completed chain-of-custody form will be maintained with the samples.

Groundwater and surface water samples will be properly packaged and shipped in accordance with procedure PROC-ES-2706, *Shipping Samples, Dangerous Goods and Non-Bulk Hazardous Materials*, which provides general technical requirements and guidelines for the proper packing and shipping of environmental samples. This procedure has been developed to reduce the risk of damage to the environmental samples, comply with regulatory requirements, verify and maintain chain-of-custody, and maintain sample temperature upon sample receipt and throughout shipment to the appropriate laboratory. Field sampling personnel will transport the samples in ice-filled coolers, as applicable, and retain full responsibility for transportation of the samples until they relinquish chain-of-custody control to the designated shipping or laboratory personnel.

4.4 FIELD MEASUREMENTS AND LABORATORY ANALYSES

Field measurements will be collected during each baseline sampling event. Sampling personnel will record field measurements of groundwater temperature, conductivity, dissolved oxygen, pH, oxidation-reduction potential (ORP), and turbidity when each well is sampled. During surface water sampling, field personnel will record field measurements of water temperature, conductivity, dissolved oxygen, pH, ORP, and turbidity when each station is sampled. These field measurements, including instrument calibration, will be performed in accordance with the most recent versions of the governing groundwater and surface water sampling procedures specified in the QAPP (or EPA-approved technically equivalent procedures) and in accordance with the manufacturer’s instrument calibration procedures.

The list of potential COCs for laboratory analyses for EMDF are found in Table 2. Laboratory analyses will be performed by laboratories designated by the Sample Management Office (SMO). The analytes, specified analytical methods, and quantitation limits required for this baseline characterization FSP are listed in Table 3. Only qualified commercial laboratories approved by the SMO will be subcontracted to provide analytical services. Laboratory analyses of the samples will be performed in accordance with the most current version of the analytical methods/procedures specified in the analytical parameter tables provided in Table 3 (or EPA-approved technically equivalent methods). Analytical results also will be reported in accordance with the units and PQLs specified in Table 3.

Applicable laboratory analytical results for groundwater and surface water samples will be reported with associated data qualifiers (and specified reason codes), as warranted, including “B” for analytes detected in the laboratory blanks, “J” for estimated values, and “U” for non-detect results.

Table 3. Baseline characterization analytical requirements

Analyte	CAS number	Method[a]	PQL	Units
Metals				
Arsenic	7440-38-2	SW846-6010B or SW846-6020	5	µg/L
Barium	7440-39-3		5	µg/L
Cadmium	7440-43-9		1	µg/L
Chromium	7440-47-3		5	µg/L
Copper	7440-50-8		5	µg/L
Lead	7439-92-1		3	µg/L
Nickel	7440-02-0		10	µg/L
Selenium	7782-49-2		5	µg/L
Silver	7440-22-4		5	µg/L
Thallium	7440-28-0		3	µg/L
Uranium	7440-61-1		15	µg/L
Chromium (VI)	18540-29-9	ASTM-D5257	6	µg/L
Mercury	7439-97-6	EPA-1631	0.001	µg/L
Radionuclides				
Carbon-14	14762-75-5	Rad-Carbon-14 Lsc	25	pCi/L
Cesium-137	10045-97-3	EPA-901.1	10	pCi/L
Iodine-129	15046-84-1	Rad-I-129 by Leps	5	pCi/L
Strontium-90	10098-97-2	SM 7500-Sr B	1	pCi/L
Technetium-99	14133-76-7	Liquid scintillation	5	pCi/L
Thorium-228	14274-82-9	Rad-Th Iso by alpha	0.5	pCi/L
Thorium-230	14269-63-7		0.5	pCi/L
Tritium	10028-17-8	SM 7500-3H B	300	pCi/L
Uranium-233/234	NS632	SM 7500-U B	0.5	pCi/L
Uranium-235/236	15117-76-1		0.5	pCi/L
Uranium-238	24678-82-8		0.5	pCi/L
Volatile Organic Compounds				
1,1,1-Trichloroethane	71-55-6	SW846-8260B	5	µg/L
1,1-Dichloroethane	75-34-3		5	µg/L
1,1-Dichloroethene	75-35-4		5	µg/L
1,2-Dichloroethane	107-06-2		5	µg/L
1,2-Dichloroethene	540-59-0		5	µg/L
trans-1,2-Dichloroethene	156-60-5		5	µg/L

Table 3. Baseline characterization analytical requirements (cont.)

Analyte	CAS number	Method[a]	PQL	Units
Acetone	67-64-1		10	µg/L
Benzene	71-43-2		5	µg/L
Carbon tetrachloride	56-23-5		5	µg/L
Chloroethane	75-00-3		5	µg/L
Chloroform	67-66-3		5	µg/L
Tetrachloroethene (PCE)	127-18-4		5	µg/L
Trichloroethene (TCE)	79-01-6		5	µg/L
Vinyl chloride	75-01-4		5	µg/L
Pesticides and Polychlorinated Biphenyls				
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	SW846-8290	0.000005	µg/L
4,4'-DDD	72-54-8	SW846-8081A	0.1	µg/L
4,4'-DDE	72-55-9		0.1	µg/L
4,4'-DDT	50-29-3		0.05	µg/L
Aldrin	309-00-2		0.05	µg/L
alpha-BHC	319-84-6		0.1	µg/L
beta-BHC	319-85-7		0.05	µg/L
Chlordane	57-74-9		0.1	µg/L
Dieldrin	60-57-1		0.24	µg/L
Endosulfan II	33213-65-9		0.1	µg/L
Endrin aldehyde	7421-93-4		0.1	µg/L
Heptachlor epoxide	1024-57-3		0.1	µg/L
Lindane (gamma-BHC)	58-89-9		0.1	µg/L
PCB-1016	12674-11-2	SW846-8082A	0.5	µg/L
PCB-1221	11104-28-2		0.5	µg/L
PCB-1232	11141-16-5		0.5	µg/L
PCB-1242	53469-21-9		0.5	µg/L
PCB-1248	12672-29-6		0.5	µg/L
PCB-1254	11097-69-1		0.5	µg/L
PCB-1260	11096-82-5		0.5	µg/L
PCB-1262	37324-23-5		0.5	µg/L
PCB-1268	11100-14-4		0.5	µg/L
Semivolatile Organic Compounds				
1,4-Dichlorobenzene	106-46-7	SW846-8270C	10	µg/L
3,3-Dichlorobenzidine	91-94-1		1	µg/L
Benz(a)anthracene	56-55-3		1	µg/L
Benzidine	92-87-5		50	µg/L
Benzo(a)pyrene	50-32-8		1	µg/L
Benzo(b)fluoranthene	205-99-2		1	µg/L
Benzo(k)fluoranthene	207-08-9		1	µg/L

Table 3. Baseline characterization analytical requirements (cont.)

Analyte	CAS number	Method[a]	PQL	Units
Benzoic Acid	65-85-0		50	µg/L
Chrysene	218-01-9		10	µg/L
Dibenz(a,h)anthracene	53-70-3		1	µg/L
Indeno(1,2,3-cd)pyrene	193-39-5		1	µg/L
Pentachlorophenol	87-86-5		10	µg/L
Other				
Calcium	7440-70-2	SW846-6010B or SW846-6020A	250	µg/L
Magnesium	7439-95-4		50	µg/L
Postassium	7440-09-7		250	µg/L
Sodium	7440-23-5		250	µg/L
Nitrate (as Nitrogen)	NA	EPA-353.2	0.1	µg/L
Cyanide	57-12-5	EPA-335.2	5	µg/L
Bicarbonate	71-52-3	EPA-310.1	NA	µg/L
Carbonate	3812-32-6		NA	µg/L
Chloride	16887-00-6	EPA-300.0	100	µg/L
Sulfate	14808-79-8		100	µg/L
Total dissolved solids	NA	EPA-160.1	2,500	µg/L

[a]An equivalent method may be used to achieve the requested quantitation limit.

ASTM = American Society for Testing and Materials
BHC = benzenehexachloride
CAS = Chemical Abstracts Service
DDD = dichlorodiphenyldichloroethane
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethane
EPA = U.S. Environmental Protection Agency
NA = not applicable
PCB = polychlorinated biphenyl
PCE = tetrachloroethene
PQL = project quantitation limit
SW846 = EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods
TCE = trichloroethene

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5. QUALITY ASSURANCE/QUALITY CONTROL MONITORING

Laboratory blanks (method blanks), trip blanks, and duplicate samples will be prepared/collected and analyzed for QA/QC purposes. Trip blank samples will be prepared for each cooler used to transport samples that were collected to be analyzed for organic compounds. In addition, laboratory QA/QC samples, including laboratory blanks, matrix spike samples, and matrix spike duplicate samples, will be prepared and analyzed by the applicable laboratory. All field and laboratory QA/QC sampling will be performed in accordance with applicable requirements specified or referenced in the WRRP QAPP.

For the purposes of baseline characterization, duplicate samples are required and will be collected from one of every 10 sampling locations during each sampling event. Laboratory analyses of the duplicate samples will be performed for the same analytes as specified in Table 3.

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6. DATA MANAGEMENT AND ASSESSMENT

The groundwater and surface water monitoring data obtained for EMDF will be managed consistent with the *Data Management Implementation Plan for the Water Resources Restoration Program, Oak Ridge, Tennessee* (UCOR 2012) and maintained in both the Project Environmental Measurements System (PEMS) and Oak Ridge Environmental Information System (OREIS) databases or equivalents. Personnel with the SMO will pre-populate the database with information (e.g., tasks and locations) specified in this FSP. As the sampling events progress, the associated field measurements and chain-of-custody information will be manually entered into the pre-populated database.

Groundwater and surface water monitoring data obtained for the purposes of baseline characterization at EMDF will be assessed, as outlined below, based on the following process for data verification, data validation, data quality assessment, data finalization, and data reporting.

Data Verification. When the required laboratory analyses are completed, qualified personnel with the applicable laboratory will upload the analytical results into the PEMS database (or equivalent) and will submit a corresponding record copy to personnel with the SMO, who will verify 100 percent of the electronic data. Verification of the data is performed to (1) resolve any discrepancies between the results loaded into the PEMS database and the corresponding hard-copy laboratory reports, (2) verify that the laboratory analytes specified for each sampling location were performed, and (3) identify any gaps in the associated chain-of-custody information or any violations of required sample holding times and/or analytical turnaround times.

Data Validation. At least 10 percent of the laboratory analytical results will undergo data validation in accordance with SMO Analytical Support Level 3 guidelines and procedures. Based on the findings of the Level 3 data validation and the professional judgment of the data validation personnel, analytical results for the applicable groundwater or surface water monitoring stations that are considered unusable will be flagged with an “R” (unusable) data qualifier (in addition to any laboratory data qualifiers). Reason codes for validation data qualifiers are documented in the PEMS database.

Data Quality Assessment. All laboratory analytical data reported for groundwater and surface water samples will undergo a computer-based electronic data assessment of data quality and usability. This data assessment, which has proven to be a highly effective supplement to the rigorous QA/QC measures required of the laboratories that perform the analyses, includes comparison of the (1) corresponding analytical results for duplicate samples, (2) organic results to associated blank sample results, (3) each radioanalyte result to the corresponding minimum detectable activity and associated total propagated uncertainty, and (4) each result with available historical monitoring data for each applicable location. Based on the outcome of the data quality assessment, analytical results deemed unusable (e.g., duplicate results that differ by an order of magnitude) will be flagged with an “R” data assessment qualifier. Data assessment qualifiers and applicable reason codes will be applied to all analytical results. These qualifiers and reason codes currently are documented in the PEMS database.

Data Finalization. After the applicable qualifiers from data validation and assessment have been applied to the results for each monitoring event, all of the environmental monitoring data will be transferred from PEMS to OREIS. The OREIS database is the final repository for all environmental data collected on the DOE ORR. To submit the data, OREIS ready-to-load files will be prepared, which include a transmittal form that documents the program (EMDF), sampling dates, and other pertinent information (project manager, etc.). Before uploading in OREIS, the data will be cleared for public release.

Data Reporting. Results of baseline characterization will be compiled in a report that will provide a summary of the characterization project; a data summary, including tables, charts, and graphs with appropriate sample identification or station location numbers, results, and units; and the data quality flags, conclusions, and recommendations.

Statistical data evaluation will be performed to provide summary statistics, distribution characteristics, and preliminary threshold/evaluation values. The threshold/evaluation values will be developed as comparative criteria for future monitoring at EMDF. Some of the processes used to develop baseline summary statistics and threshold values are discussed below.

Descriptive statistics (e.g., mean, maximum, minimum, standard deviation, etc.) will be developed for the analytes. The well data groups, or aggregates, proposed for evaluating and summarizing the data are as follows:

- All 14 wells combined
- All 14 individual wells
- Shallow wells
- Deep wells
- Upgradient wells
- Lateral/downgradient wells
- Both surface water locations combined
- Both surface water locations individually.

Table 4 shows how the 14 wells are categorized by location (relative to hydraulic gradient) and depth.

Table 4. Baseline characterization wells by gradient and depth

	Depth	
Gradient	**Deep**	**Shallow**
Upgradient		GY-021
Lateral/downgradient	GY-022	GY-023
	GY-024	GY-025
	GY-026	GY-027
	GY-028	GY-029
	GY-031	GY-030
	GY-033	GY-032
		GY-034

Threshold/evaluation values will be developed for use as the basis for comparison of baseline conditions to data generated from future monitoring events. Prior to developing threshold/evaluation values, the data distributions of each parameter will be evaluated and the presence of outliers will be assessed. The data distribution tests allow selection of the appropriate type of statistical method to be selected for those constituents for which UTLs may be calculated.

Where possible, the threshold values will be calculated using UTLs for each parameter in the 14-well data aggregate. Use of UTLs for comparative criteria is consistent with RCRA detection monitoring program regulatory guidance under 40 *CFR* 264.97(h) and EPA guidance (EPA 2009). Where the detection frequencies are too low to establish UTLs, the PQLs may be used to establish proxy threshold/evaluation values.

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